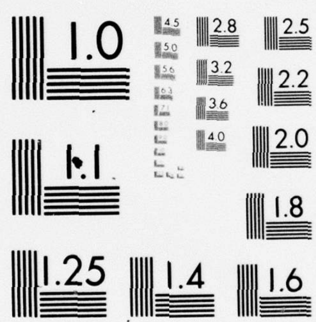
AD-A048 150 DEFENCE AND CIVIL INST OF ENVIRONMENTAL MEDICINE DOW--ETC F/G 5/10
A PORTABLE INTERACTIVE DATA ACQUISITION AND ANALYSIS SYSTEM FOR--ETC(U)
JUN 77 B C EATOCK, W W DEMMERY, R D WILLIAMS

UNCLASSIFIED DCIEM-TR-77X30 NL

1 OF 1
ADA048 150

END
DATE
FILMED
1-78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

b.s. 3

DCIEM Technical Report No. 77X30

A PORTABLE INTERACTIVE DATA ACQUISITION AND ANALYSIS SYSTEM FOR DRIVER BEHAVIOUR RESEARCH

B.C. Eatock
W.W. Demmery
R.D. Williams
D.A. Attwood

DEFENCE AND CIVIL INSTITUTE OF ENVIRONMENTAL MEDICINE
INSTITUT MILITAIRE ET CIVIL DE MEDECINE DE L'ENVIRONNEMENT

DEPARTMENT OF NATIONAL DEFENCE — CANADA

REPORT NO:	LCIEM Technical Report No. 77X30
TITLE:	A portable interactive data acquisition & analysis system for driver behaviour research.
DATED:	June 15, 1977
AUTHORS:	B.C. Eatock, W.W. Demmery, R.D. Williams & D.A. Attwood
SECURITY GRADING:	UNCLASSIFIED Initial distribution Dec 77

2- DSIS
   Plus distribution
   1- DSIS Report Collection
   1- Microfiche Section

1- DIT
1- CF Training Systems HQ.
   CFB Trenton,
   Astra, Ontario.
   Attn: Ref. Library
1- CISTI (microfiche only)
1- Transport Canada Library

BRITAIN
Ministry of Defence
5- DRIC

UNITED STATES
3- DDC/NTIS
1- Naval Training Equipment Center,
   Orlando, Florida 32813
   Attn: Technical Library

11

15 Jun[redacted]77

9 DCIEM Technical Report No. 77X30

14 DCIEM-TR-

12 24p.

6

A PORTABLE INTERACTIVE DATA ACQUISITION AND ANALYSIS SYSTEM FOR DRIVER BEHAVIOUR RESEARCH.

10
B.C. Eatock,
W.W. Demmery,

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario M3M 3B9

and

R.D. Williams
D.A. Attwood

Road Safety Unit, Transport Canada

DEPARTMENT OF NATIONAL DEFENCE - CANADA

406 986

mt

TABLE OF CONTENTS

	PAGE
ABSTRACT	v
INTRODUCTION	1
SYSTEM OVERVIEW	2
TABLE 1	3
MICROCOMPUTER SYSTEM	4
LSI-11 Microcomputer	4
Data and Program Storage	5
Data Acquisition Panel	5
Operator Interface	6
MEASUREMENT TRANSDUCERS	7
Lateral Position	7
Speed	8
Acceleration	8
Brake Pedal Force	9
Accelerator Position	9
Steering Wheel Position	9
Future Transducers	9
POWER DISTRIBUTION	10
SOFTWARE	10
CONCLUSION	11
ACKNOWLEDGMENT	12
REFERENCES	13
FIGURES	15

ABSTRACT

A portable interactive data acquisition and analysis system designed for studies of driver behaviour in roadway experiments is described. The system is microcomputer controlled and features multichannel sampling capability, on-line operator control of experimental parameters, and on-line data reduction capability. Several novel transducers are incorporated.

INTRODUCTION

The Road Safety Unit of Transport Canada has a general requirement to perform measurements of driver behaviour under actual driving conditions [1]. DCIEM was tasked to provide a car-portable system to provide these measurements.

The general requirements for the instrumentation system were:

1. True portability. It was to fit most North American cars, mid-size and up. Installation time of less than 24 hours was desired.

2. Low power consumption.

3. Modular design.

4. On-line data analysis capability.

5. On-line control over experimental procedures.

There can be as many types of instrumentation systems as there are road experiments. Performance of portable systems can be limited in many ways including:

1. sampling rate,

2. data storage,

3. degree of experimental control,

4. power requirements,

5. bulk,

6. cost

Generally, a system's bulk, power requirements and cost are directly related to its capability in terms of sampling rate, data storage, and experimental control. The more sophisticated experimental vehicles are typically equipped with fixed instrumentation and sensors. These are usually expensive, heavy, cumbersome vehicles bearing more resemblance to portable laboratories than the family sedan they are intended to simulate.

At the other extreme, the truly light weight, low-power inexpensive portable data recording systems are usually inflexible, often monitor few transducers, have slow sampling rates and limited data storage, and offer little control over the experimental parameters.

The system described herein resulted from trade-offs between the conflicting requirements of portability and capability.

SYSTEM OVERVIEW

The performance of the system is outlined in Table 1. The system also has the capability of transforming basic measures and/or combining them on line, to form complicated derivative measures.

A functional block diagram appears in figure 1. The central component is a DEC LSI-11 microcomputer, a compact machine which consumes relatively little power. When interfaced with appropriate peripheral devices and operated with commercially available software, it behaves like a conventional minicomputer. In the present configuration there are 24K (24,576) words of metal oxide semiconductor (MOS) memory, with the option to add another 4K module.

Random access bulk storage is provided by an RX01 floppy disk unit. The storage medium is a preformatted flexible diskette, or floppy disk, which can store 256K eight-bit bytes of information. The 'floppies' are used for storing data collected during the course of an experiment and providing permanent records of programs.

The other peripherals which provide communication between the operator and the computer include: a keyboard terminal with a single line gas-discharge display, a thermal printer for providing limited hard copies of numerical data, and two digital clocks. One clock reads the time of day in hours, minutes and seconds, while the other provides a millisecond readout. The two clocks can be used to time events under program control. A hardware bootstrap facilitates system initialization when the computer is turned on.

The LSI-11 communicates with the measurement transducers by means of a data acquisition module which samples up to 24 differential analog channels and performs a 12 bit analog to digital conversion for each. Under program control the computer can provide two channels of analog output, using two, 12-bit, digital-to-analog converters. In addition, there is a provision to accept either discrete inputs from digital transducers or to generate discrete signals for controling external devices (eg. light signals).

Speed is measured by a microwave radar Doppler speed sensor [2] and a measure of distance is derived by summation. Coarse and fine readouts of steering wheel position are obtained by measuring the rotation of two potentiometers. Accelerator position is obtained by measuring the displacement of the linkage at the carburettor with a linear displacement transducer. Acceleration along three axes is measured by three, sensitive, low-frequency, force-balance accelerometers, mounted orthogonally. Brake pedal force is determined using

TABLE 1

MEASUREMENT PARAMETERS

Parameters	Range	Accuracy[1]	Sampling Rate (Hz)[2]
Time (Relative)	practically unlimited	0.001 s	100
Speed	0-120 mph.	3%	10
Distance[3]	practically unlimited		
Acceleration X	0 to $\pm$ 2.5g	0.5%	20
Y	0 to $\pm$ 2.5g	0.5%	20
Z	0 to $\pm$ 2.5g	0.5%	50
Steering Wheel Position	$\pm$ 20° (fine)	0.5%	50
	$\pm$ 360° (coarse)	0.5%	50
Accelerator	0 to full	<1%[4]	50
Brake Pedal force	0 to 300 lb.	1%	50
Lateral Position	$\pm$ 2m	0.5%	50
Discrete driver responses			interrupt
Analog responses		1%	10

Notes: 1. accuracy given in % of full scale, except time

2. typical

3. distance is integrated from speed

4. nonlinear measurement, accuracy, determined by calibration table

a commercially available force transducer [3]. A sophisticated optoelectronic lane tracker, specially designed by Human Factors Research Corp., [4], measures the lateral distance of the vehicle from the roadway centreline. Eventually, it is hoped that a device to measure the distance to either a leading or trailing vehicle will be added [5].

The system is powered by a high current (130 amp) alternator which replaces the vehicle's original alternator. A reserve battery is included. A nominal twelve volts is supplied to a 12V/12V converter, 12V/5V converter and a 115V/60 Hz inverter to provide well regulated power. Maximum power consumption in the present configuration is less than 800W.

The total weight of the system (140 kg) is evenly distributed throughout the vehicle. No single component weighs more than 25 kg. The system components are typically located in the vehicle as shown in figure 2.

MICROCOMPUTER SYSTEM

The use of a microcomputer and associated peripherals for on-road data processing and control represents the most novel aspect of the instrumentation system.

LSI-11 Microcomputer

The microcomputer consists essentially of one 25 cm x 22 cm 'quad-width' board which houses the microprocessor chip set consisting of a control chip, data chip, two micro-instruction chips and an extended arithmetic/floating point arithmetic chip. The latter is an option, which was purchased to facilitate arithmetic computations.

The microprocessor includes a hardware memory stack for handling structured data, subroutines and interrupts [6]. In addition there are six general purpose and two special purpose registers for data storage or for use as pointers or accumulators.

The microprocessor board also contains 4K words of MOS memory. Another 20K of MOS memory is located on five 12.7 cm x 22 cm 'double width' modules, which follow immediately after the microprocessor board on the LSI-11 bus. MOS memory has the advantages of compactness, low power consumption, and fast access times, but requires a periodic refresh operation to maintain charge in the memory elements.

After power is turned on, the hardware bootstrap first performs a series of tests of the processor and memory, and then loads the machine with a monitor program. The monitor program which is part

of the RT-11 software system permits programming in Assembler, Fortran or Basic and contains a large number of utility programs and a library of subroutines. The LSI-11 software is identical to that of the DEC 11 series of minicomputers, so programs written for the LSI-11 can be transferred to other DEC 11 machines.

Peripherals are interfaced to the microcomputer using plug-in parallel line interface units, and serial line units. The priority assigned to a device decreases with electrical distance along the bus. The processor, memory and interface modules are housed in two backplanes which provide mechanical support, power, and signal connections. These backplanes are located in an instrument case (Figure 3), along with the data acquisition equipment, clocks, printer a $\pm$ 15V supply, and a fan. This case has dimensions 53 cm x 30 cm x 66 cm and is normally located on the back seat of the car behind the driver, on top of a similar case which houses the floppy disk unit.

Data and Program Storage

Bulk storage for the system is provided by the 'RX01' dual floppy disk unit. Its interface is located immediately after the MOS memory on the LSI-11 bus, making it the highest priority peripheral.

The floppy disk unit is a compact magnetic storage device requiring less power than other disk or magnetic tape drives. With an average access time of 500 ms, it is considerably slower than other disks but faster than tape.

During bench operation, the floppy disk is used to store system programs, user programs, and data files. During on-road operation, the operating program is normally resident in the MOS memory, and both diskettes are available for data storage. Depending on the nature of the experiment, specifically on the frequency of data samples, considerable data processing can be performed before storage.

The mounting of the floppy disk unit is illustrated in figure 3. It may be necessary to use more than two floppy disks for data storage during the course of an experiment. Therefore, LED indicators have been provided to indicate which diskette is currently being accessed, permitting the operator to change the other without halting the experiment.

Data Acquisition Panel

Data from either digital or analog transducers can be acquired. Most transducers provide analog outputs and are interfaced to a 'data acquisition module' (Analogic MP 6912 with expander). This module requires only one parallel line interface unit on the LSI-11 bus,

so all analog transducers appear physically as one device to the computer.

The data acquisition module presents the computer with 12 bits of discrete data for each sample input. Thus the data are quantized both in time and amplitude. Twelve bit quantization corresponds to a resolution of one part in 4,096 or approximately 0.024%.

Up to 24 differential input channels can be multiplexed by the data acquisition module. Differential inputs are essential since many transducers produce small full scale voltages and are connected by long cables in the noisy environment of the car.

Under command of the computer, the data acquisition module selects one of the transducer channels randomly, using a channel address supplied by the computer, or sequentially. The transducer signal is then sampled in an operation which is virtually instantaneous compared with the slow variation of transducer signals. The sampled datum is held and a 12 bit successive approximation analog-to-digital conversion is performed. The maximum throughput for 12 bit conversions is 30,000 per second.

The data acquisition module is located on the rear panel of the microcomputer instrument case. Some transducers require amplification and/or filtering and the circuits which perform these functions are located in the same area.

While no digital transducers are employed at the present time, these can be added, requiring the use of one bus interface slot each. Two 12 bit digital-to-analog converters, occupying one bus slot each, provide analog outputs to drive external devices. They are also useful in a feedback arrangement to test the operation of the data acquisition module.

Operator Interface

During experiments on the road, extensive communication between the computer and operator is not normally required. The experimenter needs the ability to command and interrogate the system and he needs a display of certain essential information.

Two-way communication is provided by a terminal (DEC RT02) which includes a key board and a one line wrap-around display. For compactness the terminal's power supply has been separated from the remainder of the circuits. The power supply sits in the trunk, while the operator is left with a small keyboard on a platform in front of him.

Since the experimenter may wish to retain numerical information after the terminal display has changed, a small thermal printer is

included which provides six columns of numerical output. The printer can be turned on or off from the panel in order to conserve power.

The time of day in hours, minutes, and seconds, is displayed by a crystal-controlled digital clock located on the computer panel (Figure 3). The computer can access this information as well as that from a digital stop clock. Although the stop clock has microsecond resolution, for our purposes, only the millisecond outputs are used. The clocks are synchronized and together provide a millisecond event timing facility. The clocks are set from the front panel, and their displays can be turned off to conserve power.

For bench operation, the RT02 terminal is usually replaced by a teletype with paper print out. The microprocessor, memory, floppy disk unit and teletype then consitute a stand-alone computer system, useful as a general laboratory tool.

MEASUREMENT TRANSDUCERS

Lateral Position

For driver behaviour studies, one of the most important but most difficult measurements to make is that of lateral position on the roadway. The Human Factors Research Inc. 'Lane Tracker' is the most sophisticated and novel transducer to be incorporated in the system to date. The lane tracker can measure lateral displacement from either a solid or dashed lane marking, or in the absence of painted lines, from the boundary between the surface and shoulder provided that there is sufficient contrast between the two surfaces.

The primary signal output is an analog voltage proportional to displacement from the lane marking. Secondary outputs include an analog video sweep signal, proportional to the light imaged at consecutive sampling points in the focal plane, and a sweep synchronization pulse train.

The lane tracker consists essentially of a Reticon LC600 line scan camera, camera AGC and computational circuitry, a power supply and mounting hardware.

The focal plane of the line scan camera contains a 256 diode linear array. The diodes are sequentially interrogated resulting in a 256 pulse video signal. The amplitude of each pulse is proportional to the light intensity incident on the diode, corresponding to light from a section of the field of view. Typically, the lateral extent of roadway scanned is three meters. The resolution, defined by the lateral dimension of a diode, is about 1.2 cm.

The lane tracker counts the number of diodes interrogated from the start of a scan until a signal from one of the diodes exceeds a preset data threshold. By adjusting scan rate, the AGC circuitry permits operation at optimum sensitivity over a range of seven F stops.

Signal conditioning circuits permit continuous tracking of striped delineations and rejection of high frequency noise associated with transient road surface characteristics.

The lane tracker draws about 1.25A at 12V.

In a typical mounting position (figure 2) the lane tracker is aimed at the road surface behind the left rear wheel. A venturi, mounted on the side of the transducer, maintains a reduced pressure inside the case to inhibit fogging of the optics.

Speed

'True' ground speed information is obtained using an RCA Doppler ground speed sensor [2,7]. The range of operation is up to approximately 120 m.p.h. Its published accuracy is 1% over the range from 20 to 70 m.p.h.

The unit transmits a 30 mW, 10.53 GHz signal which is diffusely reflected by the road surface. The back scattered component is received and mixed with the transmitted signal to separate the Doppler difference frequency. The Doppler frequency is proportional to ground speed and is in the low audio region.

Two outputs are provided, a six volt square wave with frequency equal to the Doppler frequency, and a train of constant width six volt pulses of the same frequency but with varying duty cycle, which can be integrated to obtain an analog output. The device includes a calibration and checking circuit. For our purposes, the analog output is amplified and low pass filtered to obtain a full scale output of 5V.

The dimensions of the unit are 20 cm x 13 cm x 1.6 cm. In figure 2 it is shown mounted beneath the rear bumper at a 45° angle to the road.

Acceleration

Measurement of vehicle acceleration is provided by three, orthogonally mounted, low frequency, force balance accelerometers (Columbia SA 107). Their range is $\pm$ 2.5 G's with full scale linearity of 0.2%. Their output is $\pm$ 5.0 V full scalefor $\pm$ 15 V dc excitation. The signal is filtered and applied directly to the data acquisition

module. The accelerometer package, including a spirit level, is approximately 13 cm x 13 cm x 8 cm, and is mounted on the hump in the floor of the vehicle beside the driver.

Brake Pedal Force

Brake pedal force is measured using a 'pedal force transducer' (GSE Inc. model 300) designed specifically for the job. A maximum force of 300 lbs. can be measured with an accuracy of 2% of full scale. This is a bridge type transducer which has a full scale output of 22.5 mV. Consequently the signal is amplified by a factor of 220 before being applied to the data acquisition module. Mounting this transducer is easy; it simply clamps on the pedal as shown in figure 2.

Accelerator Position

Measurement of accelerator position is accomplished using a linear displacement transducer (Celesco model PT101) attached to the carburettor linkage. This attachment is simple and unobtrusive. The computer compensates for nonlinear effects due to the nature of the linkage using a calibration table.

Displacements of up to 15 cm, can be measured with the transducer, with a resolution of 0.003 cm. The dimensions of the transducer are 13 cm x 7 cm x 6 cm.

Steering Wheel Position

The only transducer which has been manufactured in-house is the steering wheel position transducer. To get a high resolution measurement of steering wheel reversals about the centre position, a potentiometer is used which completes one revolution for every 40° of steering wheel travel. A geared pulley and 'no-slip' drive belt are used with this pot. Coarse measurement of position over the full range of steering wheel movement is provided by a ten turn potentiometer. A standard pulley and O ring are used with this pot.

Both potentiometers are miniature precision types having linearity better than 0.5% and resolution better than 0.01%. The pots are mounted on the steering wheel housing as shown in figure 2.

Future Transducers

Eventually it should be possible to monitor the distance between the test vehicle and a leading or trailing vehicle, using radar. Other transducers may be added to monitor physiological parameters, including heart and respiratory rates, and head and eye position.

POWER DISTRIBUTION

Power distribution is summarized in figure 4. The entire system is powered by the car using a high current alternator (130 A) and an extra battery. The reserve battery allows up to 15 minutes of operation of the computer system without the alternator. Therefore, in the event that the engine stops the experimenter has ample time to save all data.

A 12 V to 12 V dc converter rated at 8A, and a 12 V to 5 V dc converter at 30 A, provide well regulated dc to supply the computer, digital devices, and some transducers. A 500 Watt inverter provides 115 V/60 Hz power to devices normally operated from the line, such as the floppy disk unit and terminal. Most analog transducers require $\pm$ 15 V dc which is provided by a small modular encapsulated power supply operating from the inverter.

The system features well controlled grounds. All grounds are referenced to a single point which may be chosen anywhere on the car chassis as convenience dictates.

Control circuits allow either the alternator or reserve battery or both to be switched in. In any case, power is initially applied to the converters and the inverter loaded only by the clocks and fans. These devices are considered essential for the basic operation of the system. Another switch applies power to the processor, its peripherals and the transducers. All power is monitored by a switched meter on the power control unit, and by signal lights on the computer control panel.

SOFTWARE

Software for the system may be conveniently classified in three categories:

1. general purpose
2. diagnostic, and
3. operational software.

General purpose software is purchased as a package (DEC RT-11) with the microcomputer. It includes utility programs for microcomputer operation and permits programming in Assembler, Fortran or Basic. A library of subroutines is provided. With a good knowledge of RT-11 and either Fortran or Assembler, it is possible to write routines to acquire data from the transducers, and store the data on diskette. Using this approach, a program has been written to sample

up to nine transducers every 100 ms, and store their outputs and a possible marker. This program has been used for transducer testing and early experiments.

Diagnostic software for checking the microcomputer was also purchased (DEC RXDP-11) in a convenient floppy disk based package, useful for exercising and checking the microcomputer, including memory, instructions, and interfaces. The diagnostic programs can be run in either stand alone, chained, or interactive mode. Since the package is modular other diagnostic programs can be added.

To run experiments in which many transducers are sampled and calculations are performed on-line, a dedicated system program is being developed. This system program will give the experimenter control over such parameters as sampling rate, channel to be selected, start/stop, and functions to be evaluated. The program will be modular so that it will be possible to add routines, or modify existing routines, without disturbing its overall framework. To save memory space it will not be necessary to load routines which are not required for an experiment. With this program, it is estimated that up to 15 channels can be sampled at 10 ms intervals.

CONCLUSION

This system has been operating on the road since Spring 1977. Its success has been made possible by recent advances in microcomputer and data acquisition technology and continued progress in these fields will probably lead to higher sampling rates and relatively lower costs. In the meantime, it provides a unique opportunity to study behaviour in actual driving situations in a quantitative manner.

ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions of the following individuals and groups to this project: Mr. G.T. Chillcott, Mr. G. Stevens, Mr. H. Kuksin, Mr. M.C. Boyd, Mr. W. Fong, the DCIEM photoarts department, and shop.

REFERENCES

1. ATTWOOD, D.A., Proposal for the development of a portable data acquisition and analysis system for the Road Safety Unit of the Ministry of Transport, submitted to D/R&MVTS, Dec. 74.

2. RCA Labs, David Sarnoff Research Centre, Princeton, N.J.

3. GSE Inc., Livonia, Michigan.

4. Human Factors Research Inc., Goleta, California.

5. Technical Evaluation Services Ltd., Ottawa, Canada.

6. LSI-11, PDP-11/03 User's Manual, Digital Equipment Corp., Maynard, Mass., 1975.

7. JOHNSON, H.C. & PRESSER, A., Automotive Doppler Radar Speed Sensor, RCA PE-585, RCA Labs, Princeton, N.J., 1973.

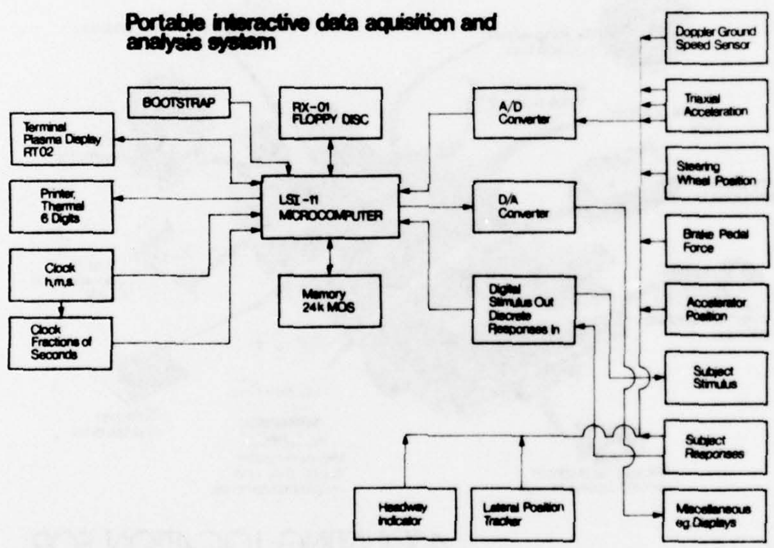


Figure 1: Functional block diagram of the portable interactive data acquisition and analysis system.

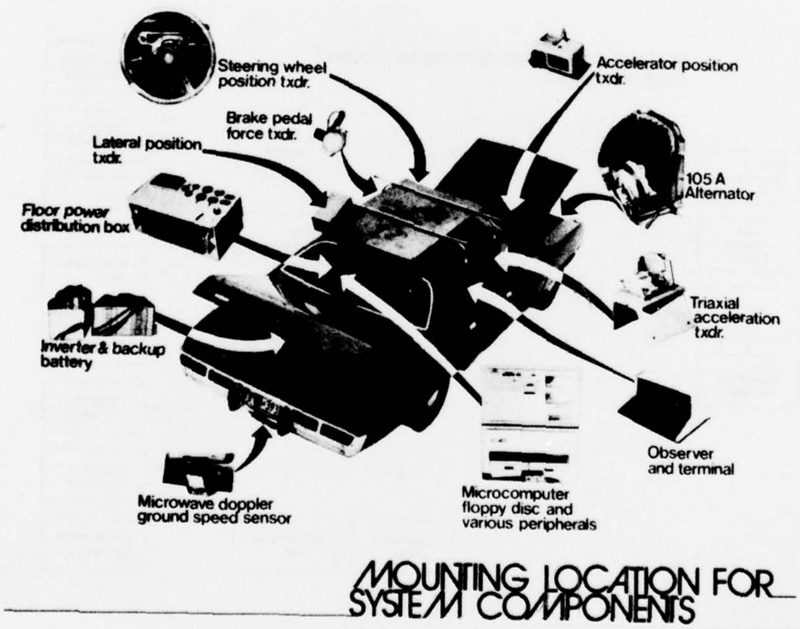


Figure 2: Mounting locations for system components.

Figure 3: Major system components benched. Left to right: reserve battery, inverter, power distribution module, microcomputer and floppy disk unit, terminal and power control box.

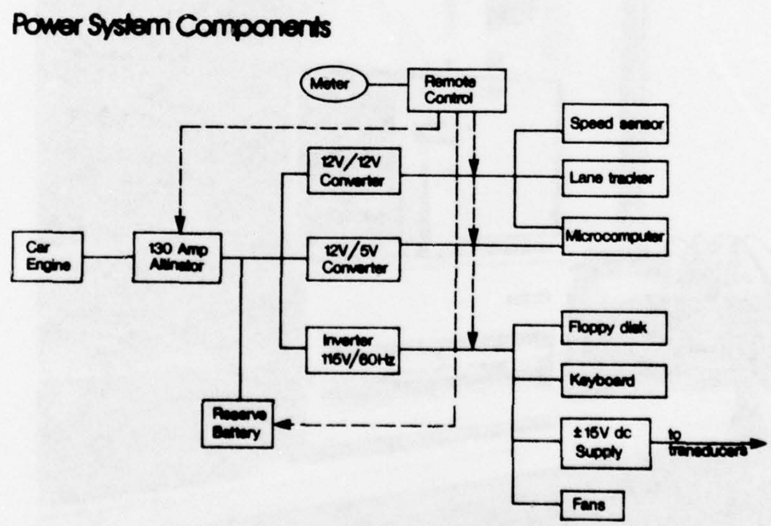


Figure 4: Block diagram of power system components.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATING ACTIVITY DCIEM	2a. DOCUMENT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. DOCUMENT TITLE

A PORTABLE INTERACTIVE DATA ACQUISITION AND ANALYSIS SYSTEM FOR DRIVER BEHAVIOUR RESEARCH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Technical

5. AUTHOR(S) (Last name, first name, middle initial)

Eatock, B.C. Williams, R.D.
Demmery, W.W. Attwood, D.A.

6. DOCUMENT DATE June 15, 1977	7a. TOTAL NO. OF PAGES 21	7b. NO. OF REFS 7
8a. PROJECT OR GRANT NO.	9a. ORIGINATOR'S DOCUMENT NUMBER(S) 77X30	
8b. CONTRACT NO.	9b. OTHER DOCUMENT NO.(S) (Any other numbers that may be assigned this document)	

10. DISTRIBUTION STATEMENT

Unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING ACTIVITY DCIEM

13. ABSTRACT

A portable interactive data acquisition and analysis system designed for studies of driver behaviour in roadway experiments is described. The system is microcomputer controlled and features multichannel sampling capability, on-line operator control of experimental parameters, and on-line data reduction capability. Several novel transducers are incorporated.

DSIS
70-241

Unclassified

Security Classification

KEY WORDS

data, acquisition, analysis, storage, driver, behaviour, vehicle, portable, interactive, low power, microcomputer, transducers, automotive, instrumentation

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the organization issuing the document.

2a. DOCUMENT SECURITY CLASSIFICATION: Enter the overall security classification of the document including special warning terms whenever applicable.

2b. GROUP: Enter security reclassification group number. The three groups are defined in Appendix 'M' of the DRB Security Regulations.

3. DOCUMENT TITLE: Enter the complete document title in all capital letters. Titles in all cases should be unclassified. If a sufficiently descriptive title cannot be selected without classification, show title classification with the usual one-capital-letter abbreviation in parentheses immediately following the title.

4. DESCRIPTIVE NOTES: Enter the category of document, e.g. technical report, technical note or technical letter. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the document. Enter last name, first name, middle initial. If military, show rank. The name of the principal author is an absolute minimum requirement.

6. DOCUMENT DATE: Enter the date (month, year) of Establishment approval for publication of the document.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the document.

8a. PROJECT OR GRANT NUMBER: If appropriate, enter the applicable research and development project or grant number under which the document was written.

8b. CONTRACT NUMBER: If appropriate, enter the applicable number under which the document was written.

9a. ORIGINATOR'S DOCUMENT NUMBER(S): Enter the official document number by which the document will be identified and controlled by the originating activity. This number must be unique to this document.

9b. OTHER DOCUMENT NUMBER(S): If the document has been assigned any other document numbers (either by the originator or by the sponsor), also enter this number(s).

10. DISTRIBUTION STATEMENT: Enter any limitations on further dissemination of the document, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this document from their defence documentation center."

(2) "Announcement and dissemination of this document is not authorized without prior approval from originating activity."

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (S), (C), (R), or (U).

The length of the abstract should be limited to 20 single-spaced standard typewritten lines; 7½ inches long.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a document and could be helpful in cataloging the document. Key words should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context.